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Palaeoecology and feeding evidence of decapod crustaceans on some shells of gastropods from the Pliocene of Masserano (Biella, NW Italy)

Abstract - Garassino *et al.* (2004) described some genera of brachyurans and anomurans from the Pliocene of Masserano (Biella, Piedmont – NW Italy). The coeval presence in the same palaeoenvironment of shells belonging to different species of gastropods, all damaged in a similar way, is probably due to the predatory activity of two genera of malacofagous decapods, *Calappa granulata* Linnaeus, 1758, and *Pagurus* sp., discovered in the Masserano locality.

Key words: Crustacea, Decapoda, palaeoecology, feeding, Pliocene, Italy.

Riassunto - Paleoecologia e tracce di predazione di crostacei decapodi su alcune conchiglie di gasteropodi del Pliocene di Masserano (Biella – NO Italia).

Garassino *et al.* (2004) hanno descritto alcuni generi di brachiuri e anomuri del Pliocene di Masserano (Biella, Piemonte – NO Italia). La presenza nello stesso paleoambiente di conchiglie appartenenti a diversi generi di gasteropodi, danneggiati nello stesso modo, è probabilmente dovuta all'attività predatoria di due generi di decapodi malacofagi, *Calappa granulata* Linnaeus, 1758, e *Pagurus* sp., rinvenuti a Masserano.

Parole chiave: Crustacea, Decapoda, paleoecologia, predazione, Pliocene, Italia.

Introduction

Garassino *et al.* (2004) reported the presence of brachyurans and anomurans from the Cenozoic of Piedmont (NW Italy). The studied genera were previously reported in some localities, such as Candelo and Cossato (Biella), Cocconato (Asti), and Morbello-Case Cherpione (Alessandria), but *Calappa granulata* Linnaeus, 1758, and *Pagurus* sp. were reported for the first time from Masserano (Biella). The presence of these two decapods was documented by many movable fingers and incomplete chelae.

The Pliocene levels of Masserano also preserve a rich and well documented mala-

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cological fauna, in addition to echinoderms and rare teeth of teleosteans and chondrichthyans, reported by E. Sismonda (1846, 1861), Bellardi (1872-1890), Sacco (1890-1904), Zuffardi Comerci (1929), and Aimone & Ferrero Mortara (1983).

The palaeontological collection of the Museo Civico di Storia Naturale di Milano preserves a small sample of molluscs from Masserano from which the specimens of gastropods were selected. The traces of damage made by decapod crustaceans are observable. This study has the purpose to point out some palaeoecological evidence connected to the predatory behaviour of some decapod crustaceans reported in the same locality without relevant investigations of the composition of the malacofauna.

Geological setting

The fossiliferous levels of Masserano (Biella) crop out along the eroded banks of Osterla River, located S of the village. These levels consist of coarse sands and grey silty sands alternating with arenaceous levels of Pliocene age, 4 m thick (Garassino *et al.*, 2004).

Material

The studied sample, housed in the paleontological collection of the Museo Civico di Storia Naturale di Milano (MSNM), consists of 17 shells in different states of preservation, belonging to some genera of gastropods, divided as follows:

Preyed specimens: *Gemmula contigua* (2 specimens, MSNM i26562), *Turritella (Haustator) vermicularis* (MSNM i26563), *Hexaplex? rudis* (MSNM i26565), *Cerithium* sp. (2 specimens, MSNM i26566), *Turricola dimidata* (MSNM i26567), *Nassarius* cfr. *N. inaequalis* (MSNM i26568), *Fusinus lamellosus* (MSNM i26569), *Turricola* sp. (2 specimens, MSNM i26573), *Bufonaria marginata* (MSNM i26577) (Figs. 1, 2).

Preyed specimens with traces of previous regenerated attacks: *Turritella (Haustator) vermicularis* (MSNM i26571), *Niso acarinatoconica* (MSNM i26572) (Fig. 3 a, b).

Specimens with only traces of regenerated attacks: *Turritella* cfr. *T. pliorecens* (MSNM i26570), *Gemmula contigua* (MSNM i26574), *Nassarius* cfr. *N. semistriatus* (MSNM i26575) (Fig. 3 c, d, e).

Palaeoecological evidence

In the fossil record the effects of the interactions between the predatory behaviours of decapod crustaceans and molluscs are not common. In fact no decapods have been discovered in the fossil record in a predatory action or in an attitude that can be connected with the feeding. Therefore only observations on living genera of decapods are available to explain and correlate the characteristic damages on the shells of many fossil molluscs, discovered in many Cenozoic outcrops in the world. This characteristic behaviour has been noted in the Jurassic, correlated with the appearance of the first brachyurans.

The nutritive predation of decapod crustaceans on the molluscs (bivalves, gastropods and scaphopods) was observed in specimens living in captivity (aquarium) (Bishop, 1975) (Fig. 4) and directly in nature by Cadée (1968) who reported the evidence of this kind of predation on the shells of several living gastropods, dredged at a depth of 25 m at Ria de Arosa Bay, Galizia (Spain), including *Ancilla glandiformis* Lamark, *Nassarius semistriatus* Brocchi, and *Turritella communis* Risso (Fig. 5 a, b, c). Baluk & Radwanski (1997) reported evidence of predation on fossils from the Polish Miocene, such as *Columbella curta* Dujardin, *Euthria puschi* Andrzejowski, *Clavatula laevigata* Eichwald, and *Sveltia inermis* Pusch. Predation fossil record is also described by Papp *et al.* (1947) in specimens, such as *Euthria intermedia* (regenerated) from the Austrian Miocene, and *Clavilithes parisiensis* (preyed) from the French Eocene (Fig. 6 a, b), putatively made by pagurids. One of the authors (G. Pasini) reported that along the northern coast of Madagascar, *Calappa* grabs the prey wrapping it with its chelipeds, blocking it under the venter and slowly cutting the shell with one chela starting from the outer lip of the gap to the growth line, while the other chela takes part in the action, keeping the shell in favourable position and making the damage, such as in the fossil *Turricola dimidata* (MSNM i26567) (Fig. 7).

Brett (1990) and Zipser & Vermeij (1978) reported that usually brachyurans and anomurans with strong chelae, able to crush the shells, use two different methods of attack, while other crustaceans, such as the stomatopods, use methods completely different. In fact these methods can use a direct action, sharp and continuous, like nippers, using almost exclusively the entire inner sides of the movable fingers of the chelae, or using only the tip of the chelae in order to break a small pieces of the outer lip of the shell to reach the prey. These three strategies of attack imply a behaviour and acquired method, oriented to the result (=feeding) and connected to the shape and biomechanics of the chelae (as already described by Feldmann, 2003). Boucot (1990, p. 168-169) reported that usually the attack starts from the outer margin of the mouth of the shell, close to the siphonal channel, after extending toward the inner of the shell. The incision develops almost parallel to the opposite side of the lip, starting more or less at the height of the anal channel, along the growth line inside the last whorl in order to enlarge the gap of the shell thus reaching the soft parts. This action causes a typical wound that usually traces the natural curvature of the movable fingers of the predator. Moreover, Hyden & Forest (1980, fig. 1) reported a rare event of damage not strictly connected to a predatory action by *Pagurus clifdenensis*, (early Miocene, New Zealand), preserved inside the damaged shell of *Struthiolaria subspinosa* in which the cutting made on the mouth of the shell is evident, allowing the entry of the crustacean with appropriate size of the abdomen. In this case we observe a different strategy aimed to shape the opening of the shell, making a precise vertical and subrectilinear cut in order to modify the margin of the last turn, obtaining an outline similar to the original shape. The result of this new outline of the *labrum* is that the left cheliped was used like an operculum in order to protect the crustacean inside of the shell. In three specimens of our sample, we observed an additional different predatory method, with the attack of the columella margin in *Bufo naria marginata* (MSNM i26577) and a double fracture in *Niso acarinatoconica* (MSNM i26572), and *Cerithium* sp.

(MSNM i26566) (Fig. 8 a, b, c) where an accessory hole of ellipsoidal shape is located in the last whorl of the shell. In any case, the final shape of the trace, made by the cracking of the shell, is very similar for all decapods with some natural exceptions. Moreover, this method of attack is not always successful both either in living or fossil decapods. In fact many shells of gastropods show a regrowth after an attack, documented by the presence of healed callosity on the shell, along the profile of the damage made prior to regeneration and regrowth of the shell. This regeneration is well figured for instance by Baluk & Radwanski (1977).

This effect is evident in our sample, above all in the following specimens: *Turritella (Haustator) vermicularis* (MSNM i26571), *Turritella* cfr. *T. pliorecens* (MSNM i26570), and *Gemmula contigua* (MSNM i26562) which show traces of two regenerations (Fig. 9 a, b, c). Moreover *Bufo naria marginata* (MSNM i26577), and *Nassarius* cfr. *N. semistriatus* (MSNM i26575) show an evident trace typical of further predation made by carnivorous gastropods, such as muricids and naticids (Fig. 10 a, c). Also, in this case the shape of the hole, based on the comparison with some living forms, allows recognising the predator by the perforation strategy of the shell. In fact, the circular holes with rounded margin and truncated conic section and parabolic walls are typical of the predatory attacks made by naticids (Boucot, 1990, p. 164-167) (Fig. 10d). These traces are ascribed to the ichnogenus *oichmus* that correlates the typology of the hole with the predator (Brett, 1990). The holes made by muricids usually have a smaller diameter and more irregular shape, while the walls are subrectilinear in section (Boucot, 1990, p. 164-167) (Fig. 10b).

Conclusion

The studied specimens show the same characteristic damages observed on some compared specimens, living or fossil, discovered in Cenozoic outcrops of different age. Therefore, this damage can be ascribed to the predatory action of carnivorous decapod crustaceans with strong chelae, such as *Calappa* and *Pagurus* (Fig. 11 a, b). Moreover the faunal assemblage of Masserano does not reveal, at the same levels, the presence of other marine durophagous predators (e.g. fishes or cephalopods) able to make such kind of damages. Finally the variety of prey proves that these crustaceans, from a feeding point of view, were not strictly connected to the presence of only one species, behaving as opportunists not especially selective.

The observation of feeding techniques and the typology of the traces of the attack on the shells of the prey made by living pagurids, compared with the scars visible on fossil specimens belonging to different groups of gastropods, show that the same predatory behaviour is verifiable with the same morphology both in the older Cenozoic faunae and in the living one.

The comparison between the fossil and living faunae also points out that in many cases the attack has not successful or was interrupted for different reasons. In this case the molluscs were able to regrowth their shells, resuming their natural growth, even though the shells preserve the traces of the damage as scar pointing out the nature and the typology of the attack on the shells (Glaessner, 1969).

The presence in the same ecosystem of predatory crustaceans with strong chelae, such as *Calappa* and *Pagurus*, with shells of damaged or preyed gas-

tropods, allows to support the direct interaction between the two taxa, connected with an intense predatory activity like to that observable in the same Recent littoral-marine environments.

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Fig. 1 - a) *Gemmula contigua*, n. cat. MSNM i26562 (x 3.2); b) *Turritella (Haustator) vermicularis*, n. cat. MSNM i26563 (x 1.7); c) *Hexaplex? rudis*, n. cat. i26565 (x 3.2); d) *Cerithium* sp., n. cat. i26566 (x 2.1); e) *Cerithium* sp., n. cat. MSNM i26566 (x 3.5).

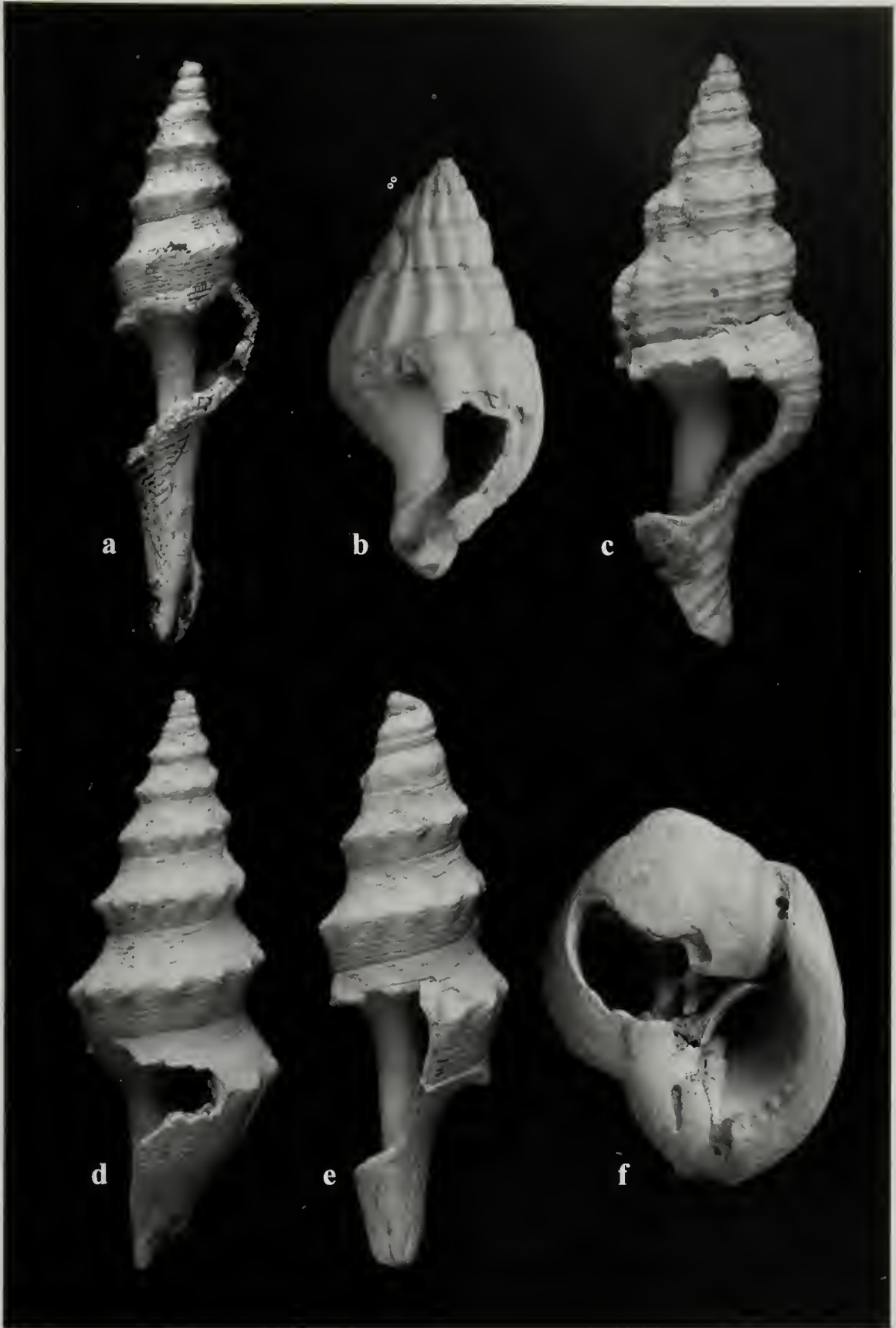


Fig. 2 - a) *Turricola dimidata*, n. cat. MSNM i26567 (x 2.2); b) *Nassarius* cfr. *N. inaequalis*, n. cat. MSNM i26568 (x 4); c) *Fusinus lamellosus*, n. cat. MSNM i26569 (x 2.2); d) *Turricola* sp., n. cat. MSNM i26573 (x 2.6); e) *Turricola* sp., n. cat. MSNM i26573 (x 2.6); f) *Bufonaria marginata*, n. cat. MSNM i26577 (x 1.6).

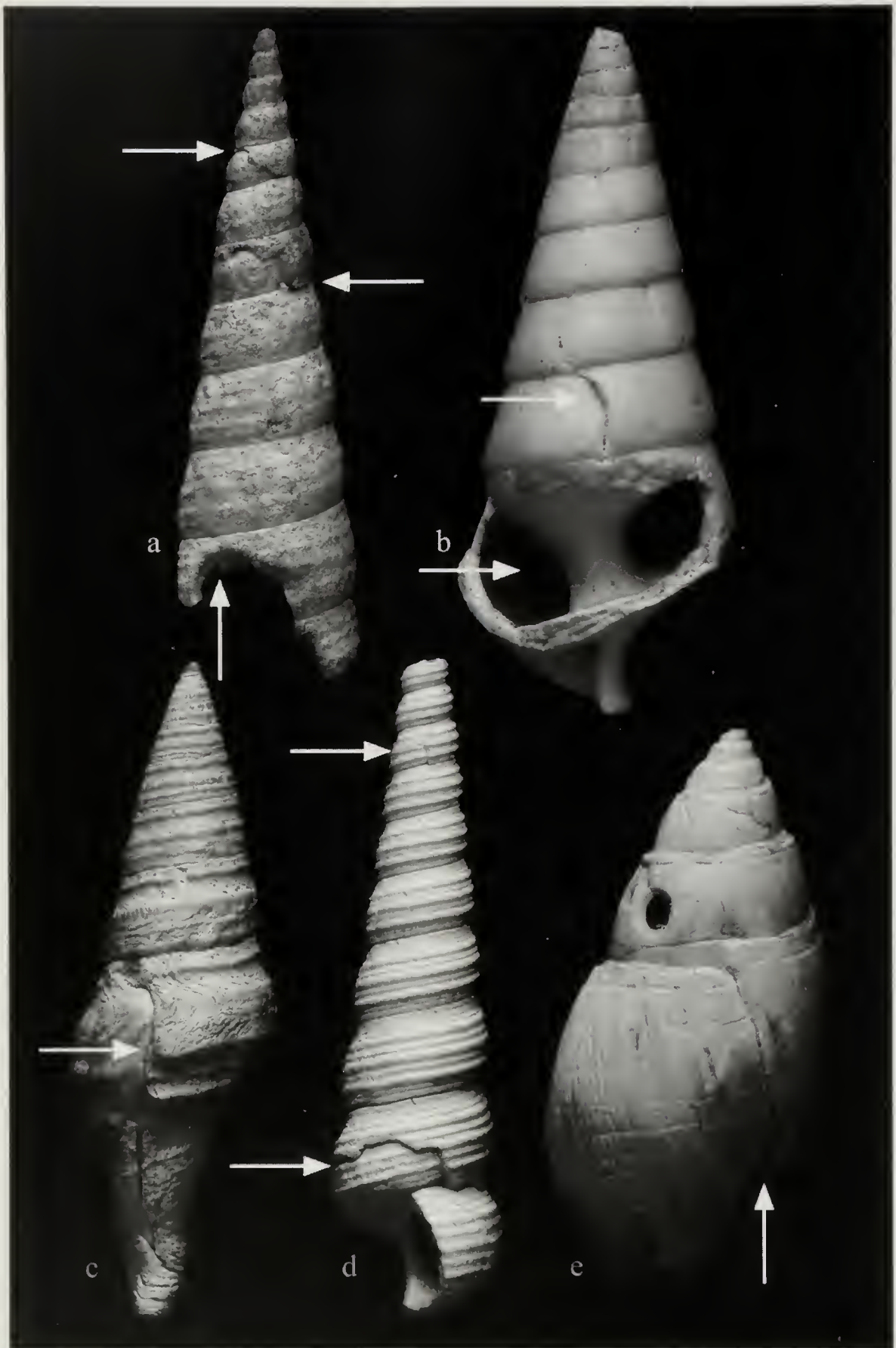


Fig. 3 - a) *Turritella* (*Haustator*) *vermicularis*, n. cat. MSNM i26571 (x 2.5); b) *Niso acarinatoconica*, n. cat. MSNM i26572 (x 4.7); c) *Gemmula contigua*, n. cat. MSNM i26574 (x 2.2); d) *Turritella* cfr. *T. plio-recens*, n. cat. MSNM i26570 (x 3); e) *Nassarius* cfr. *N. semistriatus*, n. cat. MSNM i26575 (x 4).

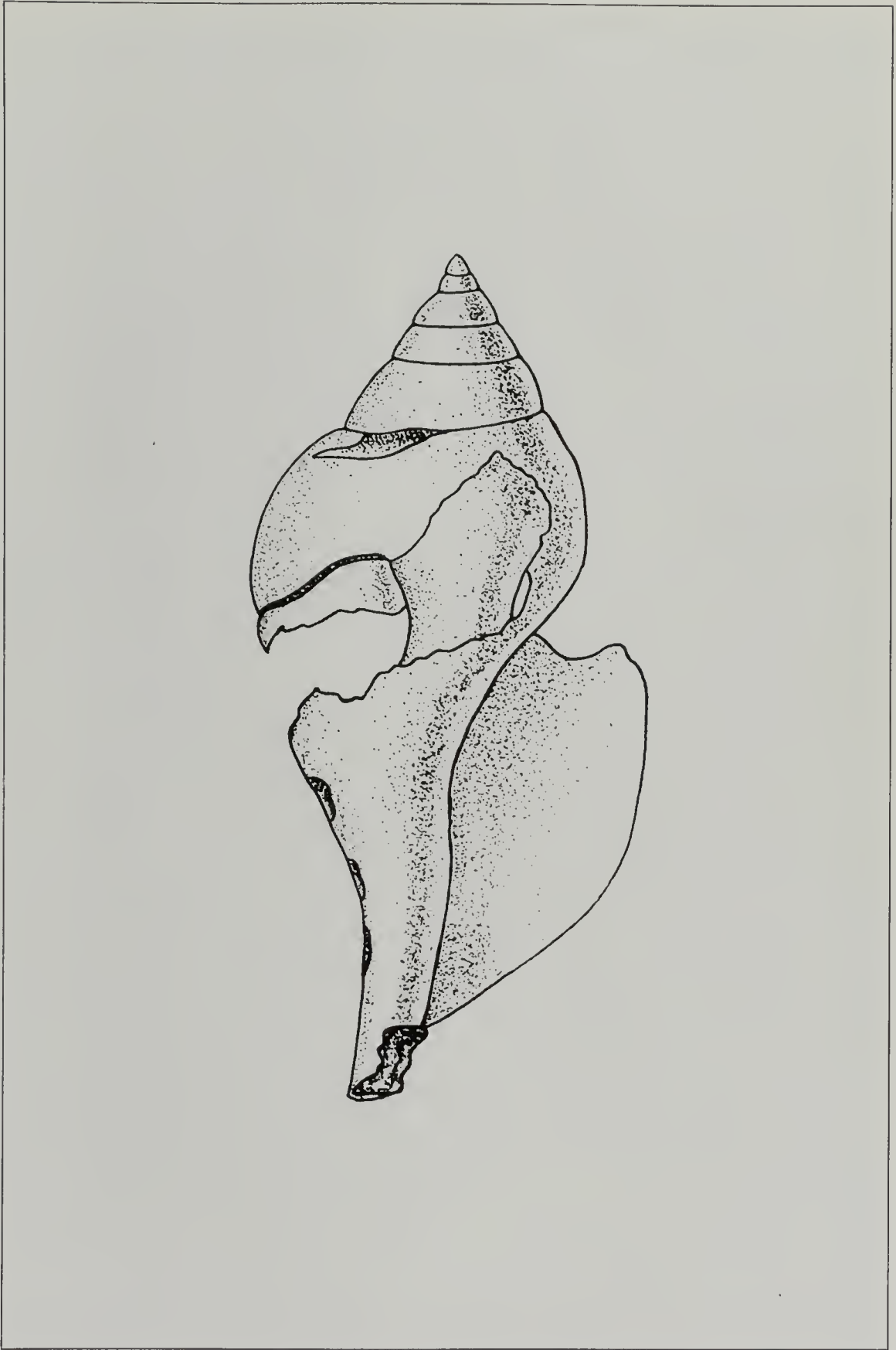


Fig. 4 - Living gastropod preyed by *Calappa* (re-figured from Bishop, 1975) (gasteropode attuale pre-
dato da *Calappa* (rifigurato da Bishop, 1975).

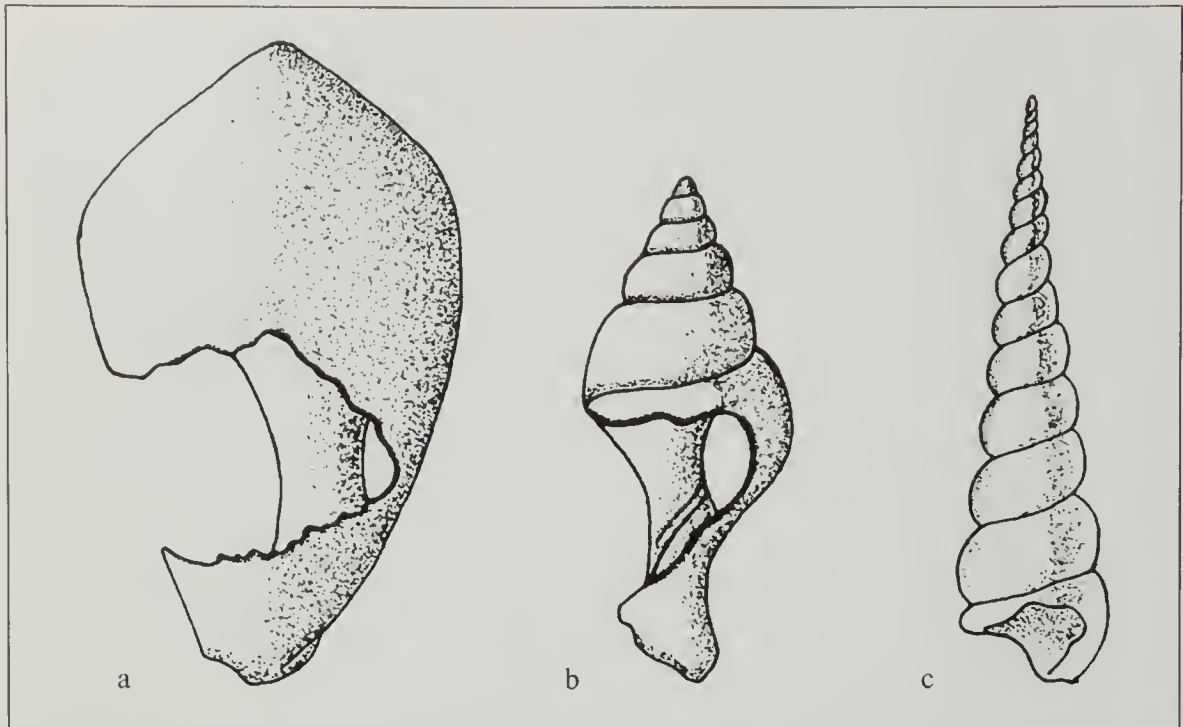


Fig. 5 - Predatory evidence by crustacean decapods on living gastropods (re-figured from Baluk & Radwanski, 1977b, and Cadée, 1968) (azione predatoria di crostacei decapodi su gasteropodi attuali (rifigurato da Baluk & Radwanski, 1977b e Cadée, 1968). a) *Ancilla glandiformis*; b) *Nassarius* cfr. *N. semistriatus*; c) *Turritella communis*.

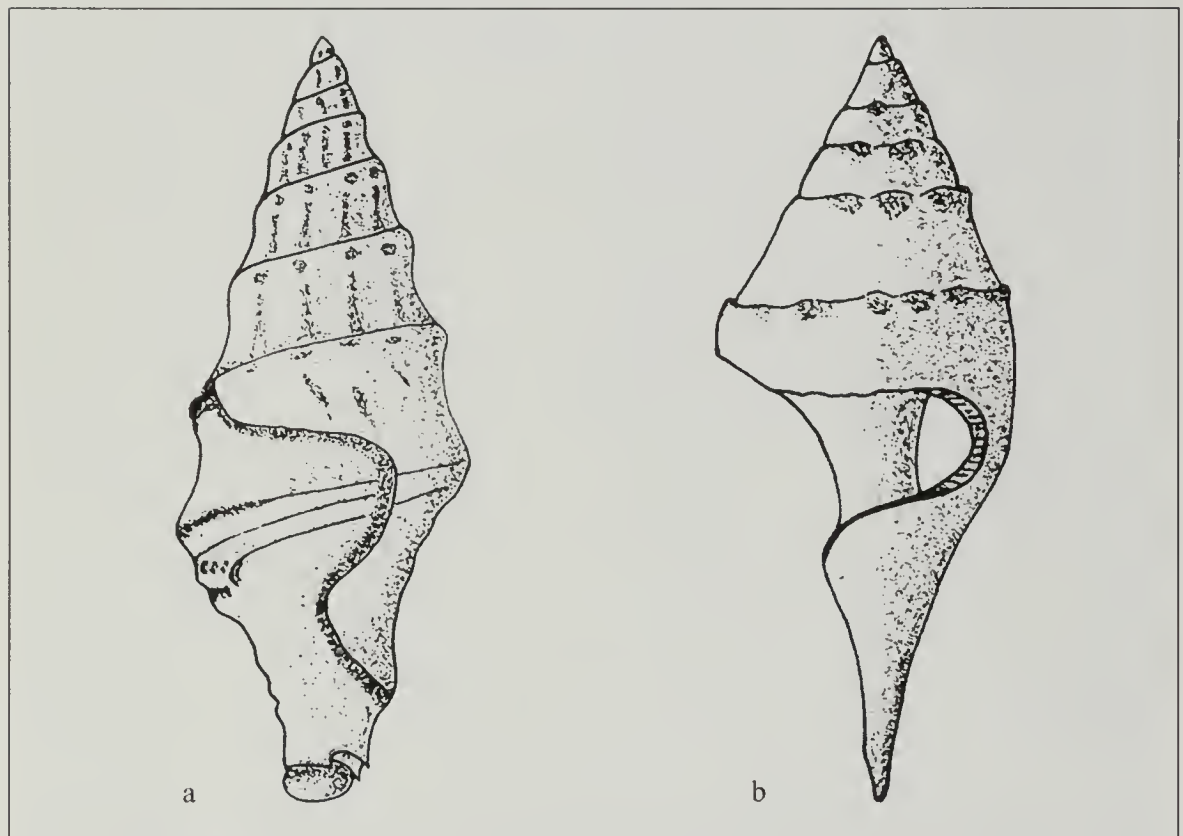


Fig. 6 - Predatory evidence by crustacean decapods on fossil gastropods (re-figured from Baluk & Radwanski, 1977b, and Glaessner, 1969) (azione predatoria di crostacei decapodi su gasteropodi fossili) (rifigurato da Baluk & Radwanski, 1977b e Glaessner, 1969). a) *Euthria intermedia* (regenerated) (rigenerata); b) *Clavilithes parisiensis* (preyed) (predata).



Fig. 7 - Predatory evidence by *Calappa* on the shell of *Turricola dimidata* (azione predatoria di *Calappa* su conchiglia di *Turricola dimidata*).

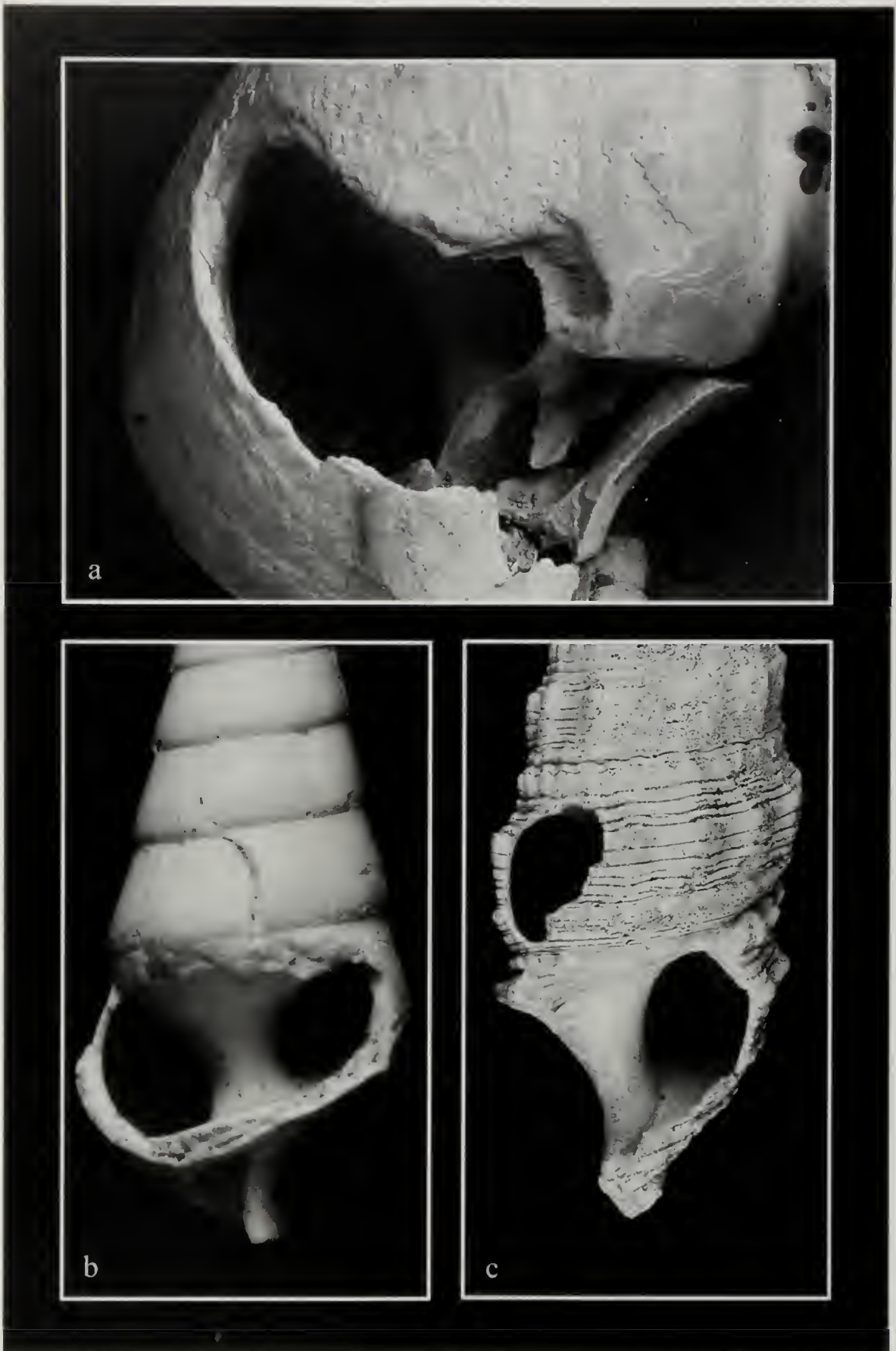


Fig. 8 - a) *Bifonaria marginata* (MSNM i26577) (x 5); b) *Niso acarinatoconica* (MSNM i26572) (x 6); c) *Cerithium* sp. (MSNM i26566) (x 2.5).

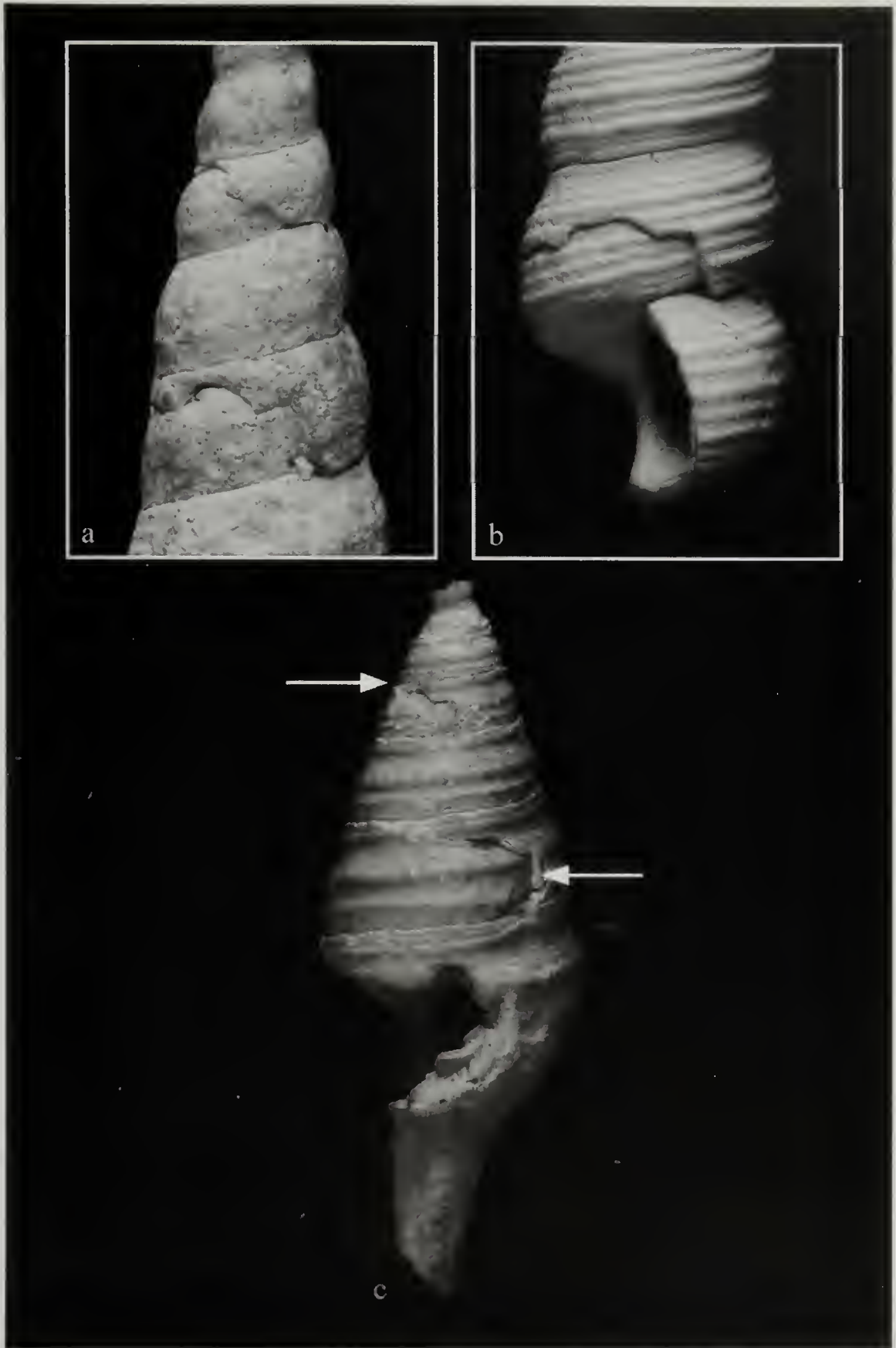


Fig. 9 - a) *Turritella (Haustator) vermicularis* (MSNM i26571) (x 7); b) *Turritella* cfr. *T. pliorecens* (MSNM i26570) (x 4.5); c) *Gemmula contigua* (MSNM i26562) (x 5).

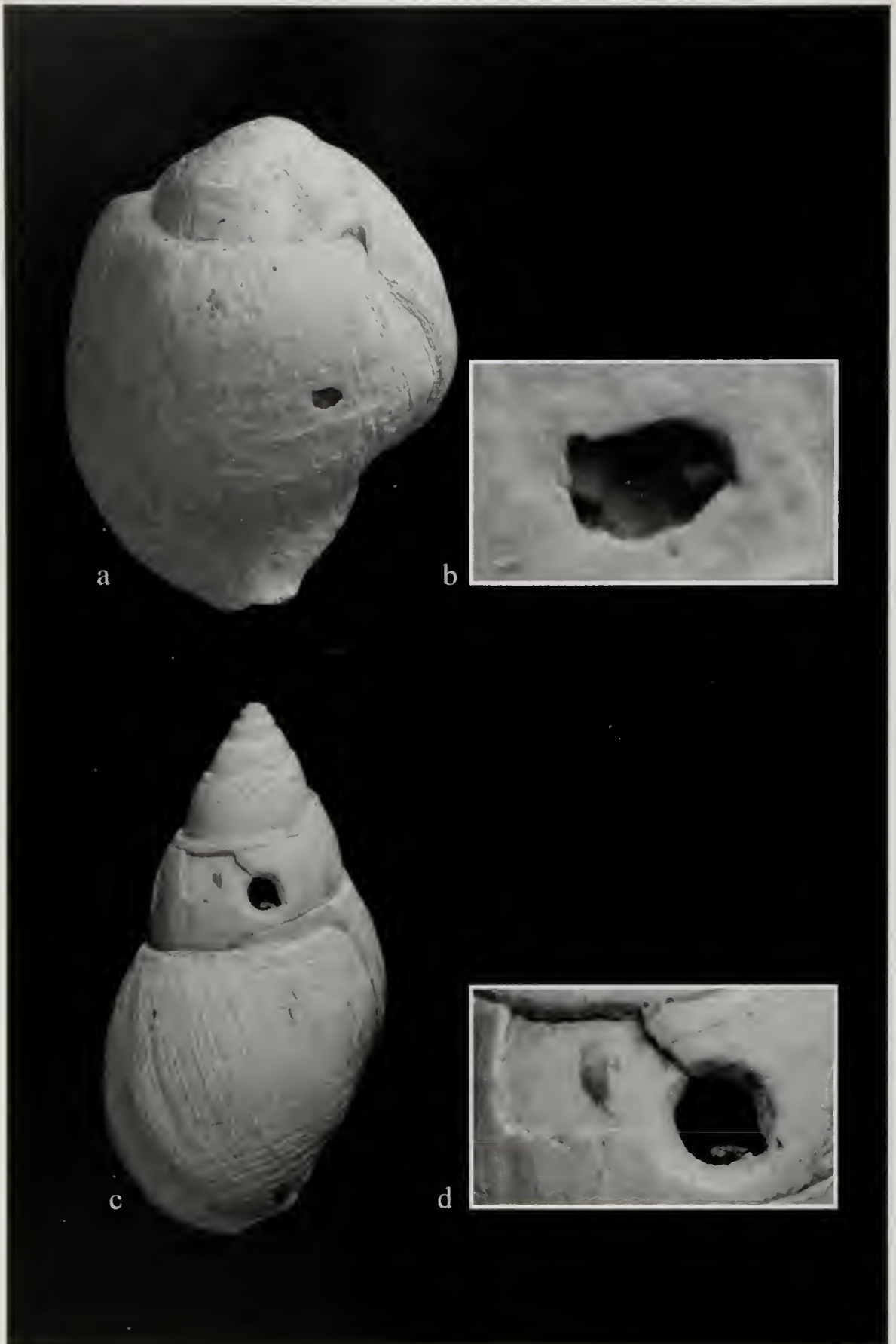


Fig. 10 - a, b) *Bufonaria marginata* (MSNM i26577) (predatory evidence by muricid) (azione predatoria di muricide); c, d) *Nassarius* cfr. *N. semistriatus* (MSNM i26575) (predatory evidence by naticid) (azione predatoria di naticide).



Fig. 11 - a) *Calappa granulata* (PU 41158) (right movable finger) (dactylus destro); b) *Pagurus* sp. (PU 41145) (inner margin of movable finger) (margine interno del dactylus).

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